

## ADVICE ON MATHEMATICAL WRITING (MATH 200/201)

The best way to learn how to write anything well is to *read* books in that subject area. Of course, students not planning to go to graduate school in mathematics or other technical subjects are not in the habit of reading technical books outside of class. (Anyone who does intend to go to graduate school should consider doing this, however.) This handout lists some writing tips when you are dealing with mathematical text.

### 1. NOTATION

- Do not begin sentences with a symbol.
  - Bad:  $x$  is positive, so it has a square root.
  - Good: Since  $x$  is positive, it has a square root.
  
  - Bad: Let  $n$  be an even number.  $n = 2m$  for some  $m \in \mathbf{Z}$ .
  - Good: Let  $n$  be an even number. Thus  $n = 2m$  for some  $m \in \mathbf{Z}$ .
  - Good: Let  $n$  be an even number, so  $n = 2m$  for some  $m \in \mathbf{Z}$ .
  
  - Bad: One solution is  $f(x) = \sin x$ .  $f(x)$  is periodic.
  - Good: One solution is  $f(x) = \sin x$ . In this case,  $f(x)$  is periodic.
- Do not use unnecessary notations when writing the statement of a theorem (or some claim in the middle of a proof).
  - Bad: Every differentiable function  $f$  is continuous.
  - Good: Every differentiable function is continuous.
  - Good: All differentiable functions are continuous.
- When introducing notation, make it fit the context. This is usually just common sense.
  - Bad: Let  $m$  be a prime.
  - Good: Let  $p$  be a prime.
  
  - Bad: Let  $X$  be a set, and pick an element of  $X$ , say  $t$ .
  - Good: Let  $X$  be a set, and pick an element of  $X$ , say  $x$ .
  
  - Bad: Pick two elements of the set  $X$ , say  $x$  and  $u$ .
  - Good: Pick two elements of the set  $X$ , say  $x$  and  $y$ .
  - Good: Pick two elements of the set  $X$ , say  $x_1$  and  $x_2$ .
  - Good: Pick two elements of the set  $X$ , say  $x$  and  $x'$ .
- Always define new notation (is it a number? a function? of what type?) and be clear about its logical standing.
  - Very bad: Since  $n$  is composite,  $n = ab$ .
  - Bad: Since  $n$  is composite,  $n = ab$  for some integers  $a$  and  $b$ .

Good: Since  $n$  is composite,  $n = ab$  for some integers  $a$  and  $b$  greater than 1.

(Why were the bad examples bad? Because *every* integer is a product, since  $n = n \cdot 1$ , so writing  $n = ab$  with no constraints on  $a$  and  $b$  is wrong.)

Bad: If a polynomial  $f(x)$  satisfies  $f(n) \in \mathbf{Z}$ , does  $f(x)$  have integer coefficients?

Good: If a polynomial  $f(x)$  satisfies  $f(n) \in \mathbf{Z}$  for every  $n \in \mathbf{Z}$ , does  $f(x)$  have integer coefficients?

- Do not duplicate the meaning of a variable within the same proof.

Bad: To show the sum of two even numbers is even, suppose  $a$  and  $b$  are even. Then  $a = 2m$  and  $b = 2m$ , for some integer  $m$ . We have  $a + b = 4m = 2(2m)$ , which is even. [Notice this “proof” showed the sum of two even numbers is always a multiple of 4, which is nonsense.]

Good: To show the sum of two even numbers is even, suppose  $a$  and  $b$  are even. Then  $a = 2m$  and  $b = 2n$ , for some integers  $m$  and  $n$ . We have  $a + b = 2m + 2n = 2(m + n)$ , which is even.

- Avoid overloading meaning into notation.

Bad: Let  $x > 0 \in \mathbf{Z}$ .

Good: Let  $x$  be an integer, with  $x > 0$ .

Good: Let  $x$  be a positive integer.

- **NEVER** use the logical symbols  $\forall$ ,  $\exists$ ,  $\wedge$ ,  $\vee$  when writing English text, and even better just avoid it altogether *except* in a paper on logic. Write out what you mean in ordinary language.

Bad: The conditions imply  $a = 0 \wedge b = 1$ .

Good: The conditions imply  $a = 0$  and  $b = 1$ .

Bad: If  $\exists$  a root of the polynomial then there is a linear factor.

Good: If there is a root of the polynomial then there is a linear factor.

Bad: If the functions agree at three points, they agree  $\forall$  points.

Good: If the functions agree at three points, they agree at all points.

- Avoid silly abbreviations, or the misuse of standard notations.

Bad: When  $n$  is  $\int$ ,  $2n$  is an even number.

Good: When  $n$  is integral,  $2n$  is an even number.

Bad: Let  $z$  be a  $\mathbf{C}$ .

Good: Let  $z$  be a complex number.

Good: Choose  $z \in \mathbf{C}$ .

## 2. EQUATIONS AND EXPRESSIONS

- If an equation or expression is important, either for later reference or for emphasis, display it on its own line. If you need to refer to it later, label it (as (1), (2), and so on) on the side. Of course, if you only need to make a reference to a displayed equation or expression immediately before or after it appears, you could avoid a label and say “by the above equation,” *etc.*

Bad: As a special case of the binomial theorem,

$$(x + y)^4 = x^4 + 4x^3y + 6x^2y^2 + 4xy^3 + y^4.$$

[suppose several lines of text are here]

By the equation 8 lines up, we see...

Good: As a special case of the binomial theorem,

$$(2.1) \quad (x + y)^4 = x^4 + 4x^3y + 6x^2y^2 + 4xy^3 + y^4.$$

[suppose several lines of text are here]

By equation (2.1), we see...

- If a single computation involves several steps, especially more than two, present the steps in stacked form.

Bad:

$$(x + 1)^3 = (x + 1)^2(x + 1) = (x^2 + 2x + 1)(x + 1) = x^3 + 3x^2 + 3x + 1.$$

Bad:

$$\begin{aligned} (x + 1)^3 &= (x + 1)^2(x + 1) \\ (x + 1)^3 &= (x^2 + 2x + 1)(x + 1) \\ (x + 1)^3 &= x^3 + 3x^2 + 3x + 1. \end{aligned}$$

Good:

$$\begin{aligned} (x + 1)^3 &= (x + 1)^2(x + 1) \\ &= (x^2 + 2x + 1)(x + 1) \\ &= x^3 + 3x^2 + 3x + 1. \end{aligned}$$

- Equations do not stand by themselves. They appear as part of a sentence and should be punctuated accordingly! If an equation ends a sentence, place a period at the end of the line. If an equation appears in the middle of a sentence, use a comma after the equation if one would naturally pause there. Sometimes no punctuation is needed after the equation. The following three examples illustrate each possibility.

Good: We call  $x_0$  a critical point of  $f$  when  $f$  is differentiable and

$$f'(x_0) = 0.$$

Good: When  $f$  is differentiable, and  $x_0$  satisfies

$$f'(x_0) = 0,$$

we call  $x_0$  a critical point.

Good: When  $f$  is differentiable, any  $x_0$  where

$$f'(x_0) = 0$$

is called a critical point.

(That the equation was displayed separately in each case simply serves to highlight its importance to the reader. It could have been included within the main text, and punctuation rules of course apply in the same way.)

### 3. PARENTHESES

- Avoid pointless parentheses.  
 Bad:  $(x + y)(x - y) = (x^2 - y^2)$ .  
 Good:  $(x + y)(x - y) = x^2 - y^2$ .  
 Good:  $(a + b)^2 - (a + c)^2 = b^2 - c^2 + 2ab - 2ac$ .  
 Good:  $(a + b)^2 - (a + c)^2 = (b^2 - c^2) + 2ab - 2ac$ . [This example is good only if the writer wants the reader to view  $b^2 - c^2$  as a special part of the right side.]
- Use parentheses to avoid confusing the meaning between a subtraction sign and a negative sign.  
 Very bad:  $(a + b) - c = -ac - bc$ .  
 Bad:  $(a + b) \cdot -c = -ac - bc$ .  
 Good:  $(a + b)(-c) = -ac - bc$ .

### 4. ITALICS

- Variables and parameters are always written in italics:  $a$ ,  $b$ , and so on. Be attentive to this when you are referring to letters in the middle of a sentence.  
 Bad: Since  $x$  is positive, it has a square root.  
 Good: Since  $x$  is positive, it has a square root.
- Avoid italic numbers like *1*, *2*, and *3*. They look disgusting, don't they? Yes, they sure do. Avoid italic parentheses such as *(,)*. They also look disgusting.  
 Bad: *If  $A$  is an invertible matrix (that is, if  $\det A \neq 0$ ), then ...*  
 Good: *If  $A$  is an invertible matrix (that is, if  $\det A \neq 0$ ), then ...*

## 5. USE HELPFUL WORDS

- Tell the reader where you are going.
  - Good: We will prove this by induction on  $n$ .
  - Good: We will prove this by induction on the dimension.
  - Good: We argue by contradiction.
  - Good: Now we consider the converse direction.
  - Good: But  $f(x)$  is actually continuous. To see why, consider...
  - Good: The inequality is strict. Indeed, if there was equality then...
- Use key words to show the reader how you are reasoning (since, because, on the other hand, observe, note), but vary your choice of words to avoid monotonous writing. This may require you to completely rewrite a paragraph.
  - Bad: We proved that if  $a^2$  is even, then  $a$  is even. Suppose  $a^8$  is even. Then  $a^4$  is even. Then  $a^2$  is even. Then  $a$  is even.
  - Good: We proved that if  $a^2$  is even, then  $a$  is even. Suppose  $a^8$  is even. Then, by successively applying the result to  $a^4$ ,  $a^2$ , and  $a$ , we see that  $a$  is even.
- Watch your spelling! If you aren't sure of the difference between "necessary" and "neccessary" or "discriminate" and "discriminant," look it up. (Canadian students may use their own flavour of spelling.)
  - Use "it's" only to mean "it is". The word "its" is on the same footing as "his," to denote possession.
  - Bad: It's clear that  $f(x)$  has a root since it's degree is odd.
  - Bad: Its clear that  $f(x)$  has a root since its degree is odd.
  - Good: It's clear that  $f(x)$  has a root since its degree is odd.
  - Good: Since  $f(x)$  has odd degree, clearly it has a root. [Write like this if you can't remember the difference between its and it's.]

## 6. PROOFREAD

Before submitting your work, read it over again. If you don't think something is well written, rewrite it. The instructor who reads your drafts and papers should be considered the second reviewer of your work. *You* are the first reviewer.